

Material Modeling Strategies for Crash and Drop Test Simulation

General Overview

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DatapointLabs
expert material testing



Material Modeling
Calibration Services

Since 1995

Expertise

- Since 1995
 - Focus on product development / CAE
 - ◆ 25 CAE codes supported
 - ◆ ANSYS, LS-Dyna in-house
 - >1,000 materials tested per year
 - ◆ Wide variety of materials
 - ◆ Over 200 types of physical properties
- Plastic
 - Rubber
 - Film
 - Metal
 - Foam
 - Composite
 - Cement
 - Ceramic
 - Paper
 - Wire
 - Fiber



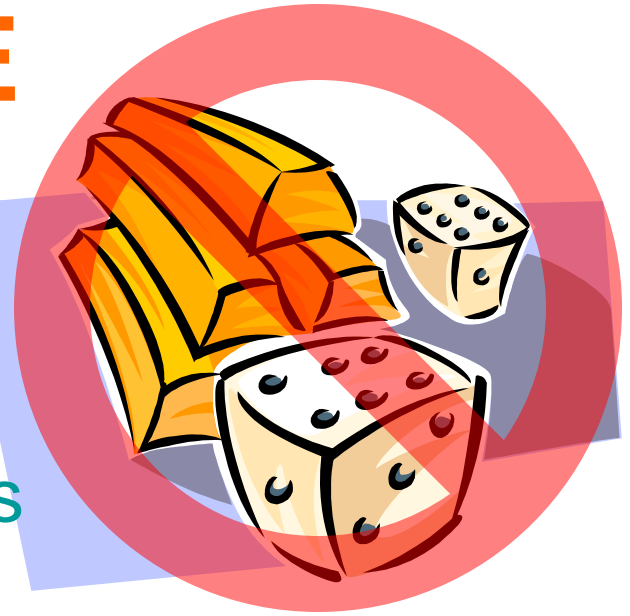
Market Base

- > 600 client companies
- Every manufacturing vertical
- Product development / R&D
- 90% US customer base
- Expanding to Europe/Asia
 - ◆ Seeking VARs / Resellers

- Aerospace
- Automotive
- Appliance
- Biomedical
- Consumer products
- Electronics
- Materials
- Pharmaceutical
- Packaging

TestPaks[®] for CAE

- Simple to order
- Global availability
- Testing to CAE requirements
- Data in CAE-ready format
- Available via Matereality
- 120 material models supported



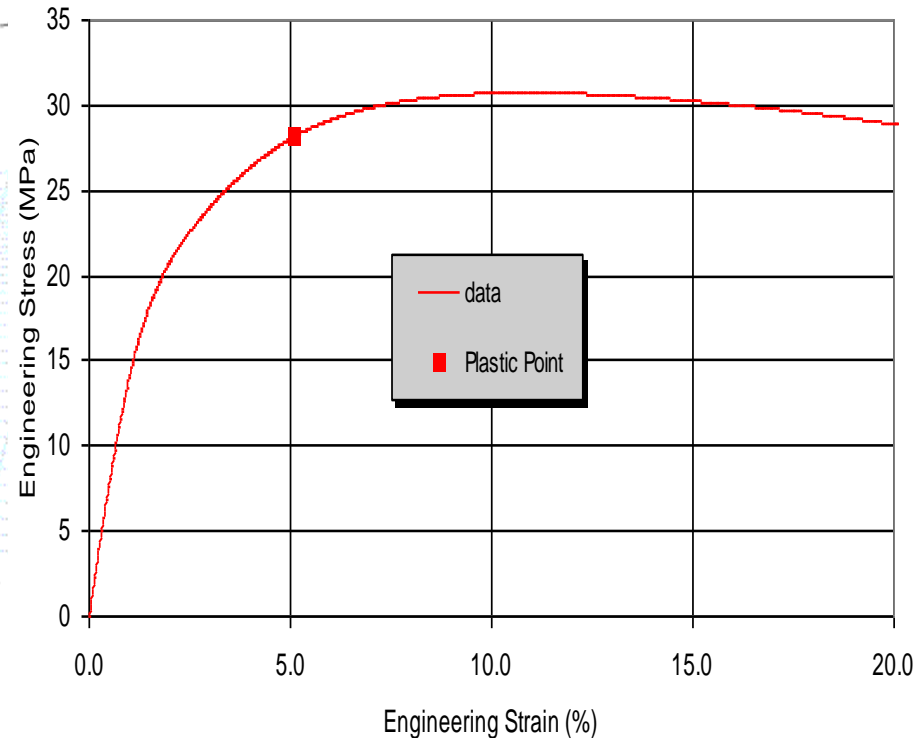
no gamble

Objective

- Many LS-DYNA models used for plastics crash simulation
- Common models are not designed for plastics
- Develop best practices for adapting common LS-DYNA models to plastics

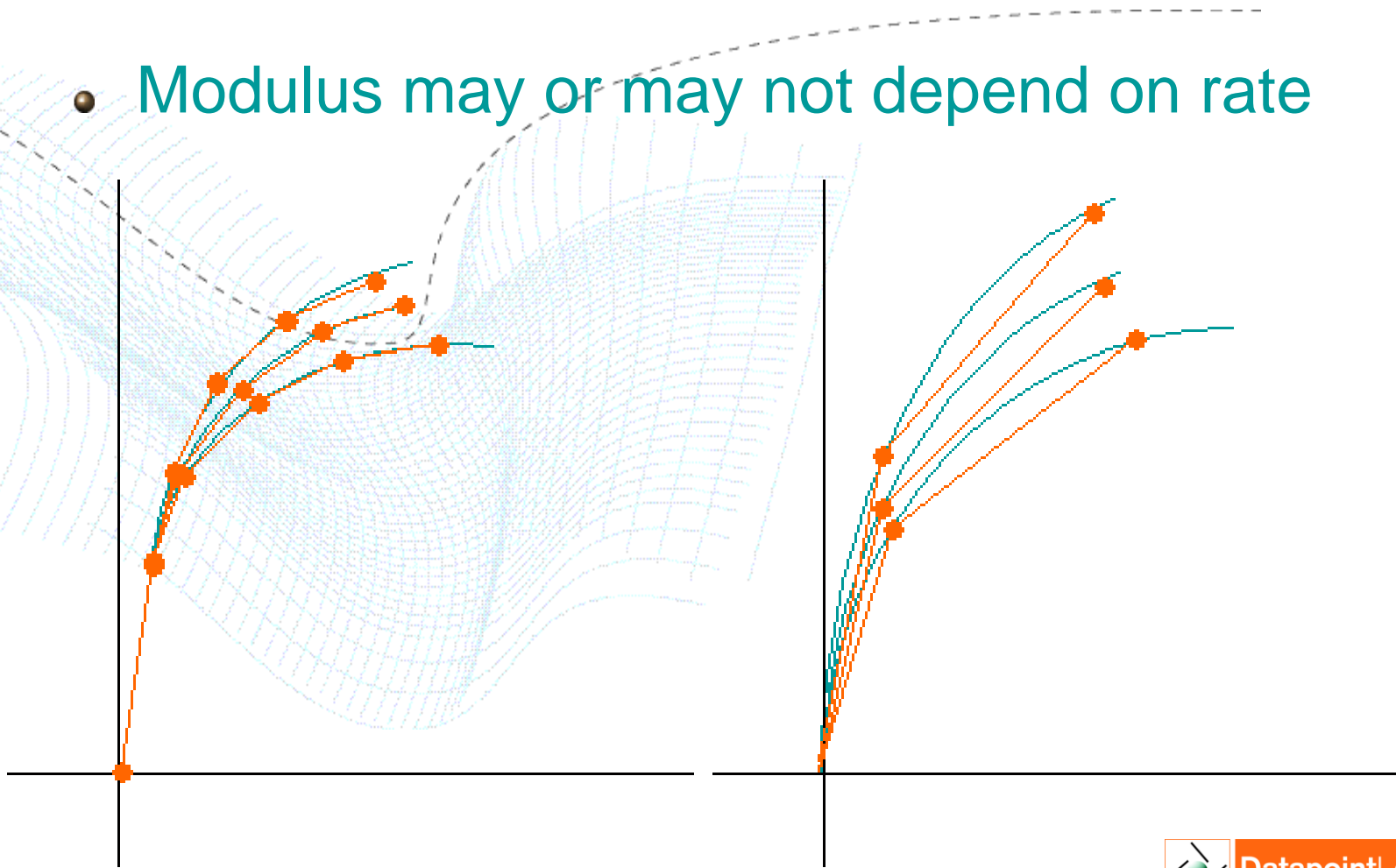
Plastics Behavior - Basics

- Non-linear elasticity
- Elastic limit well below classical yield point
- Significant plastic strains prior to yield
- Post-yield with necking behavior



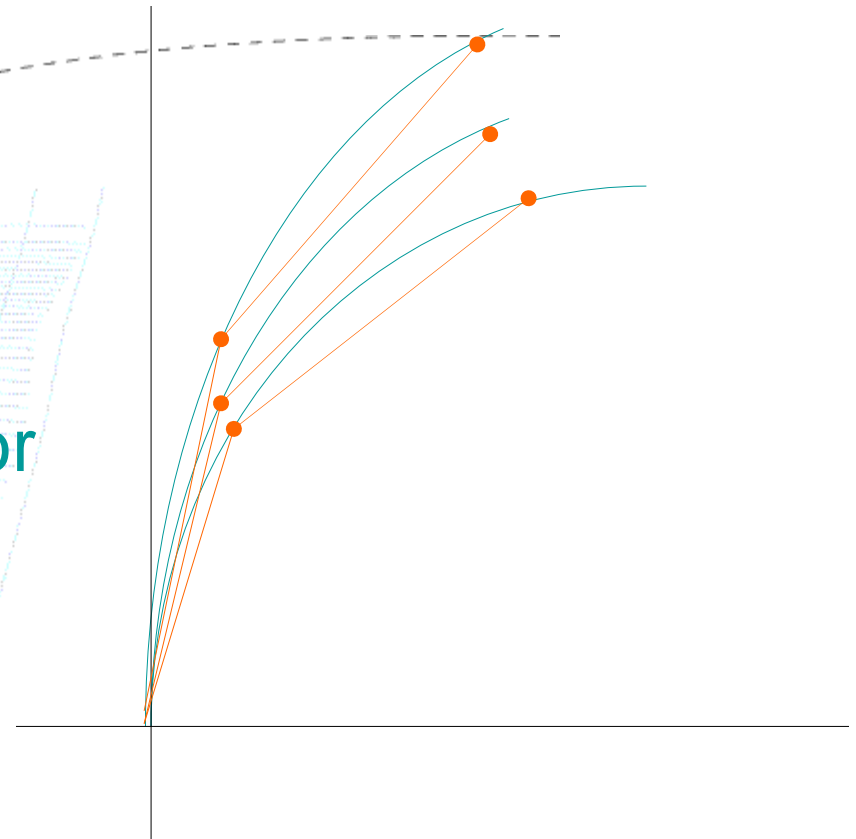
Plastics Rate Effects

- Modulus may or may not depend on rate



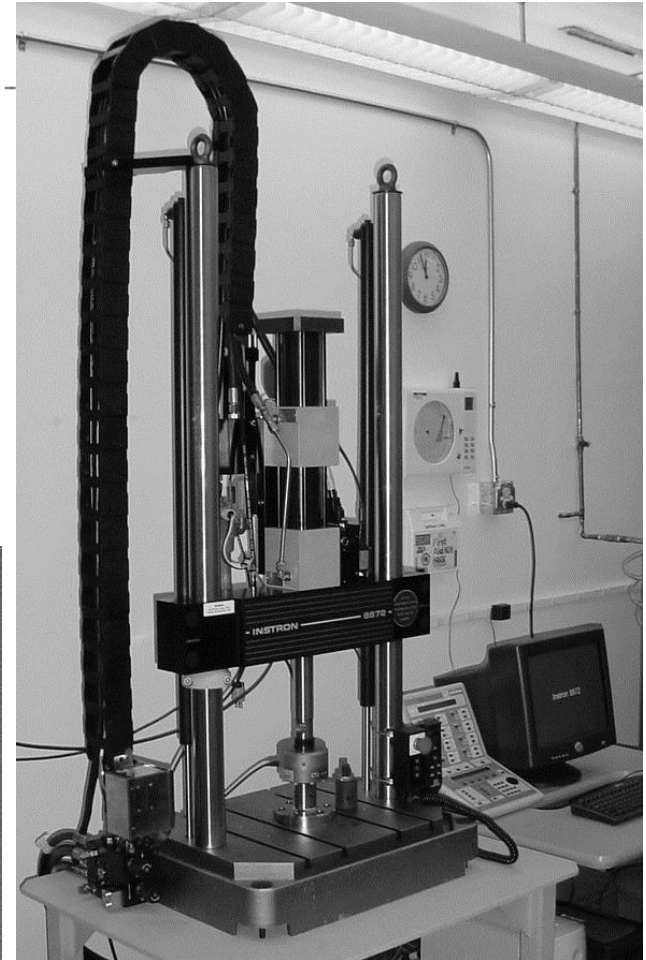
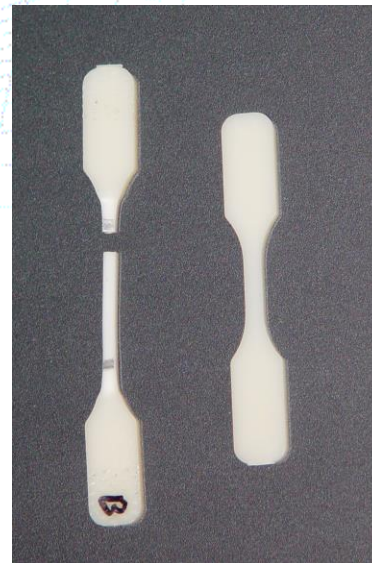
Effect of fiber fillers

- Higher modulus
- Small strain to failure
- Brittle failure
- No post-yield behavior
- Anisotropy



Material Testing

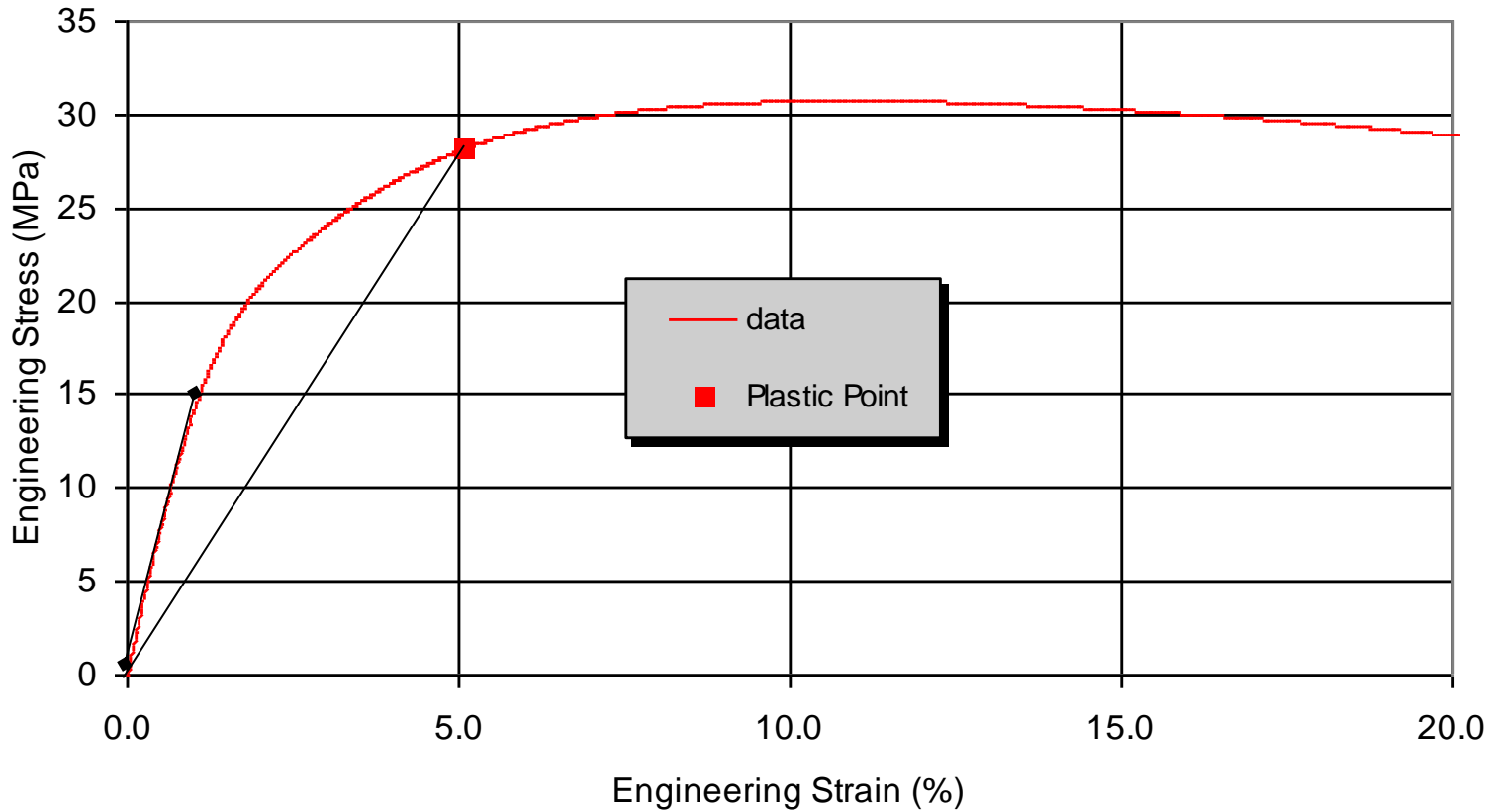
- Instron servo-hydraulic
 - ◆ Dynamic load cell
 - ◆ Tensile strain rate to 100/s
 - ◆ Tensile, compressive or flex



MAT 24 – Ductile plastics

- Modulus is not rate dependent
- Large strains to failure
- Post-yield necking
- Plasticity curves vary with strain rate
- Failure strain independent of strain rate

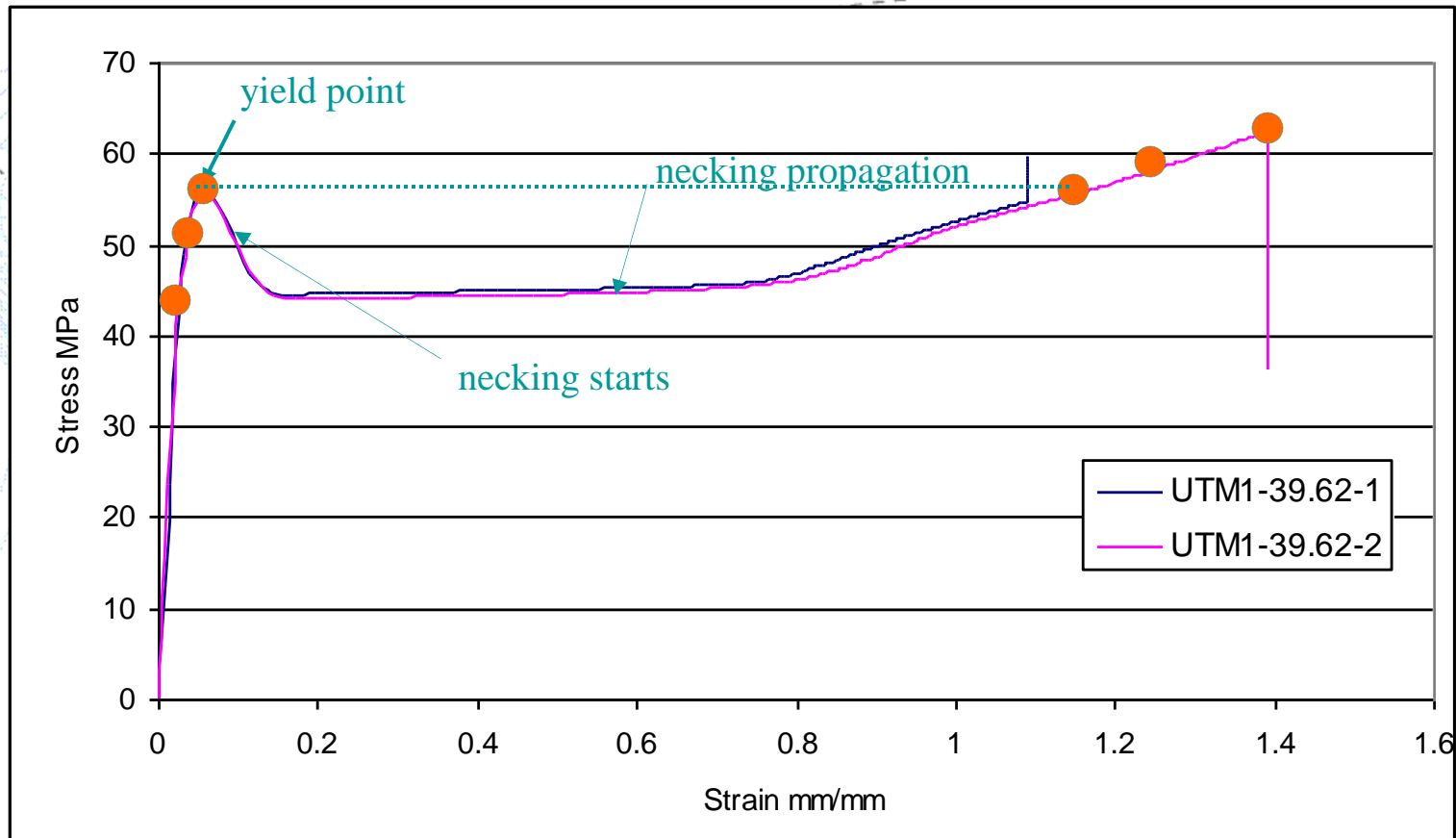
MAT 24 – Choosing EMOD



MAT 24 – Plasticity

- Discretize curve
- Calculate EPS for each ES
- $EPS_{max} > FAIL$
(FAIL = element deletion strain)

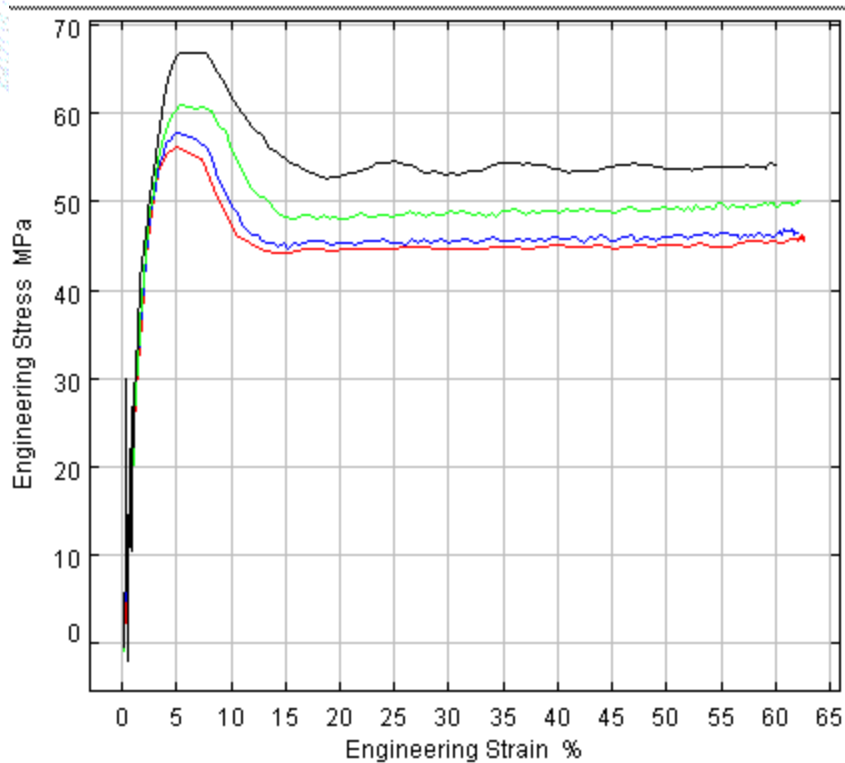
Post-yield with necking



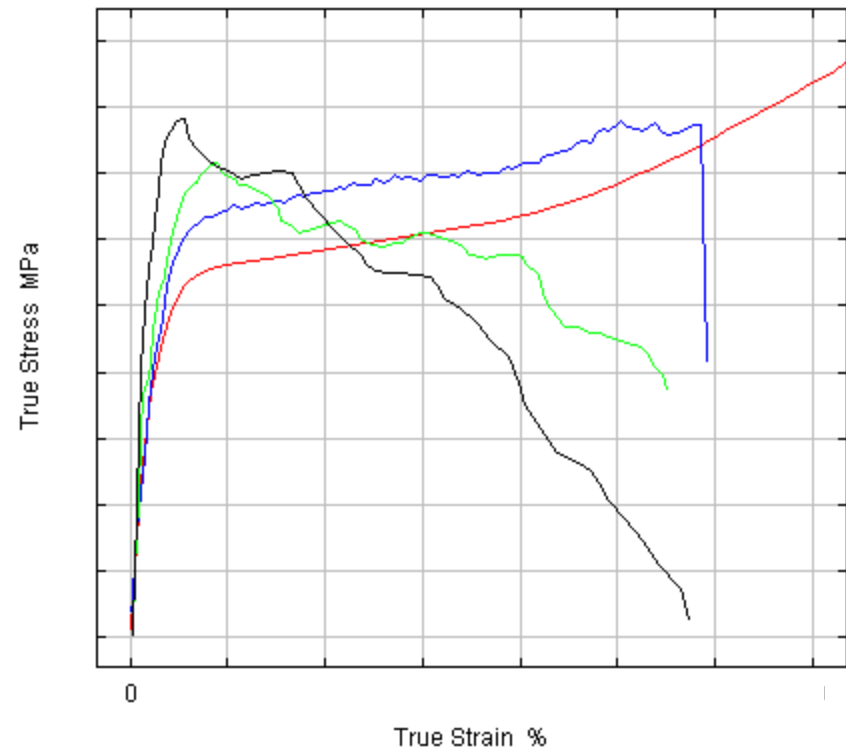
MAT 24 – Fail Limitations

- When FAIL f(strain rate)

Engineering Tensile Stress-Strain Curves



True Tensile Stress-Strain Curves



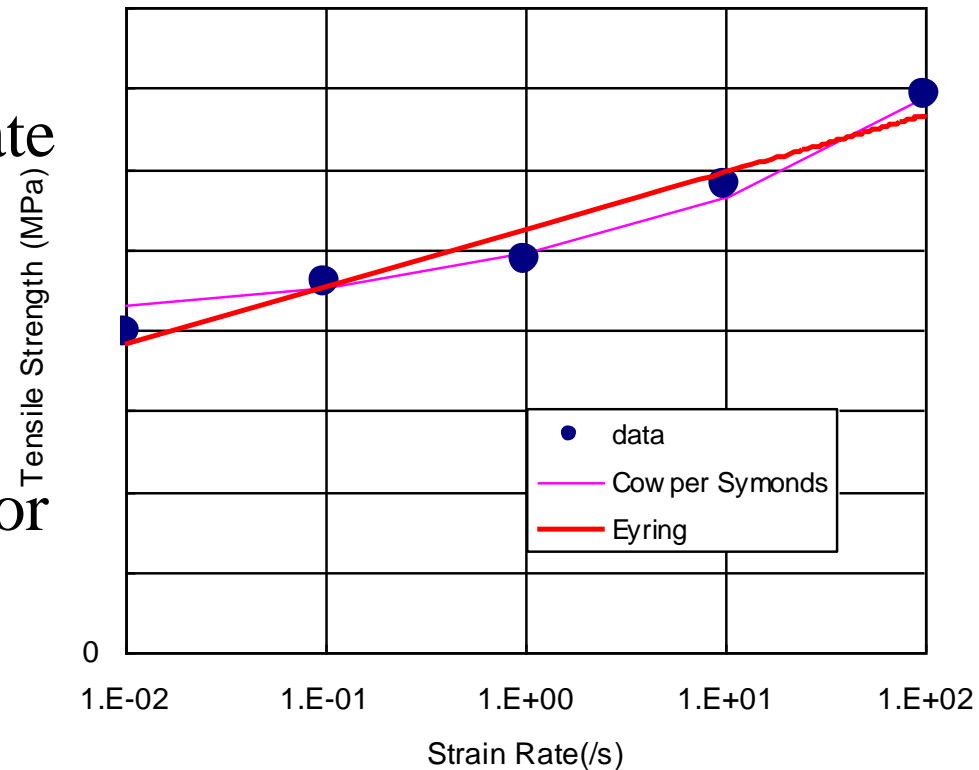
MAT 24 – Rate Dependency

Cowper Symonds

- ◆ Does not correlate well with plastics rate dependency

LCSR

- ◆ Capture model independent behavior



MAT 24 – LCSR-Eyring

- Eyring Model
 - ◆ Yield stress v. log strain rate is linear
 - ◆ Best form for plastics
- Fit yield stress v. log strain rate data to Eyring equation
- Submit as table using LCSR



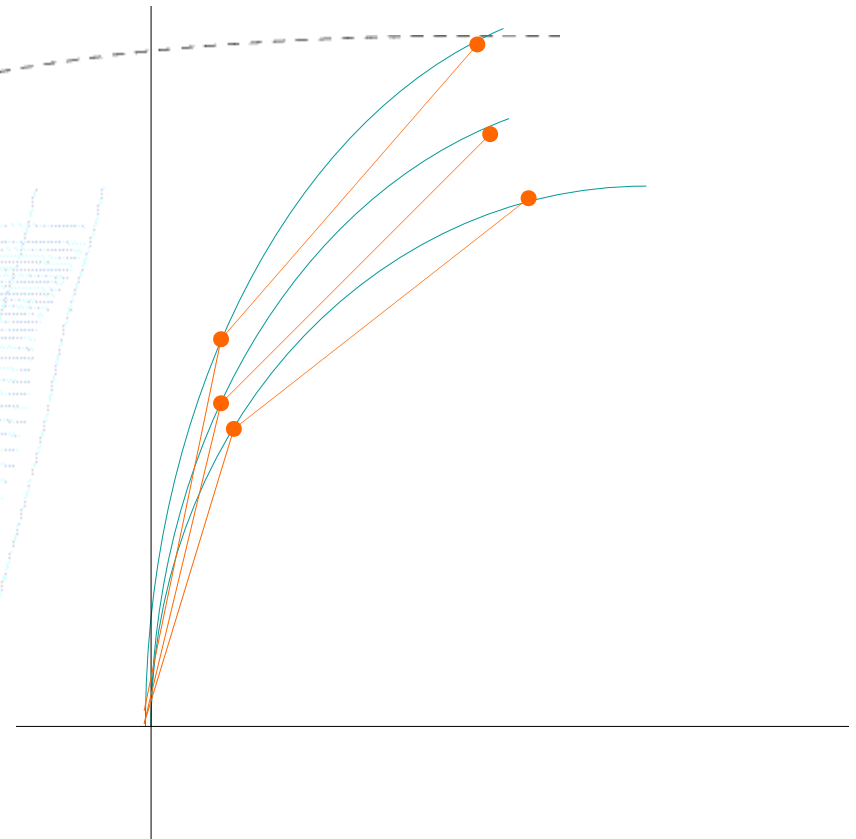
MAT 19 – Brittle plastics

- Modulus is rate dependent
- Small strains to failure
- Brittle failure
- Failure strain decreases with increasing strain rate



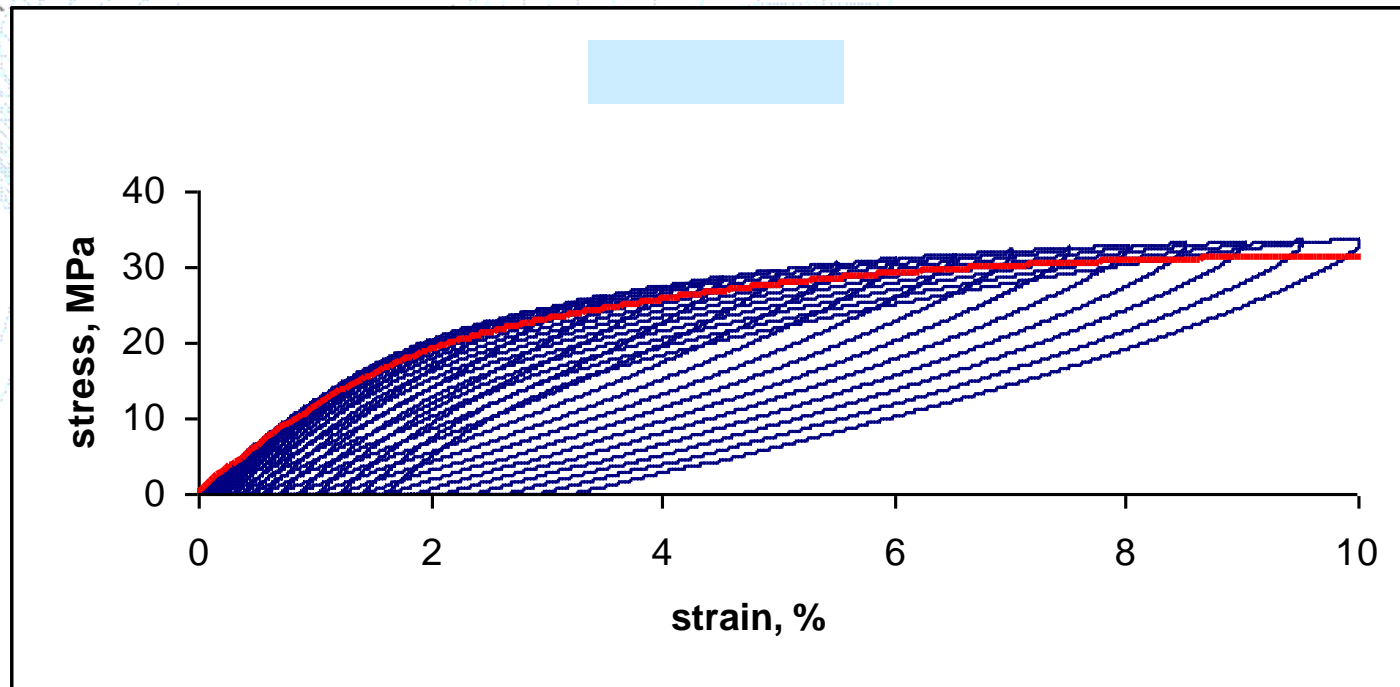
MAT 19 – Methodology

- Determine elastic limit at quasi-static strain rate
- Use elastic limit for von-Mises yield
- Define failure
 - ◆ failure stress v. strain rate table



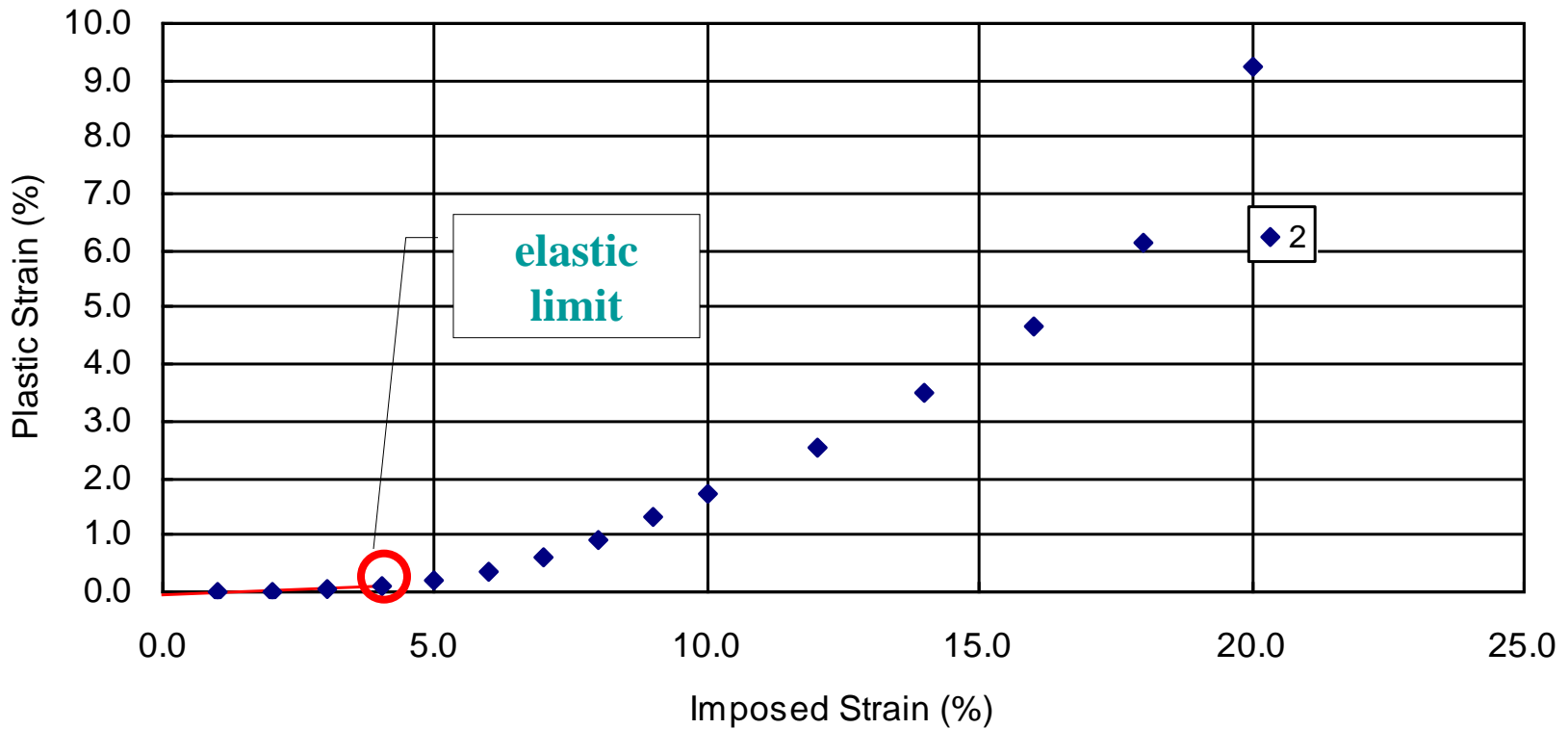
Finding the elastic limit

- Cyclic loading curves



Elastic Limit

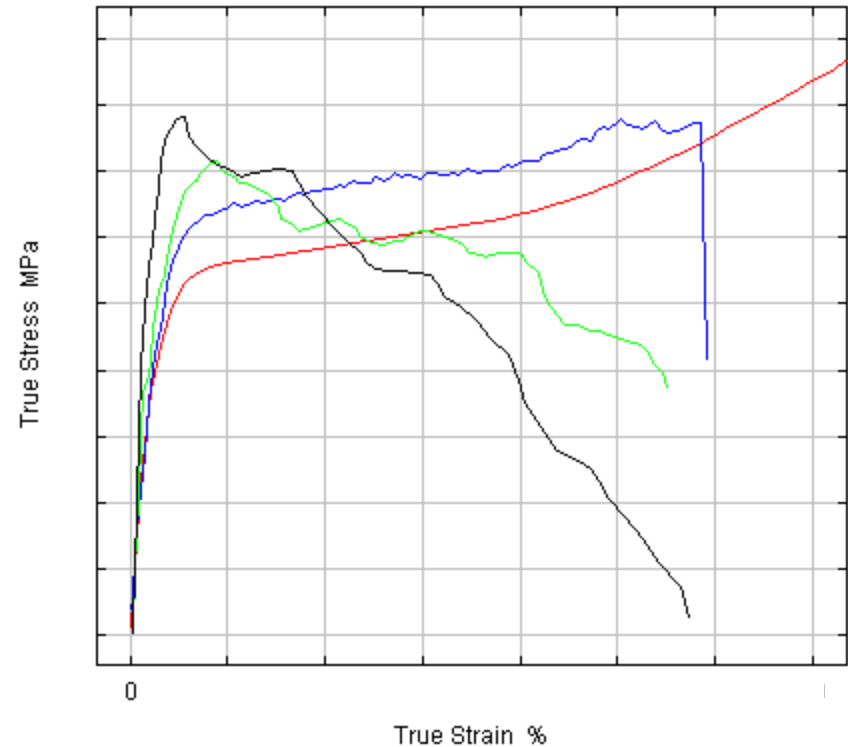
Residual v. imposed strain



MAT 89 – Ductile-brittle

- Non-linear behavior
- Failure depends on strain rate
- Can handle ductile-brittle transitions
- Uses stress-strain curve

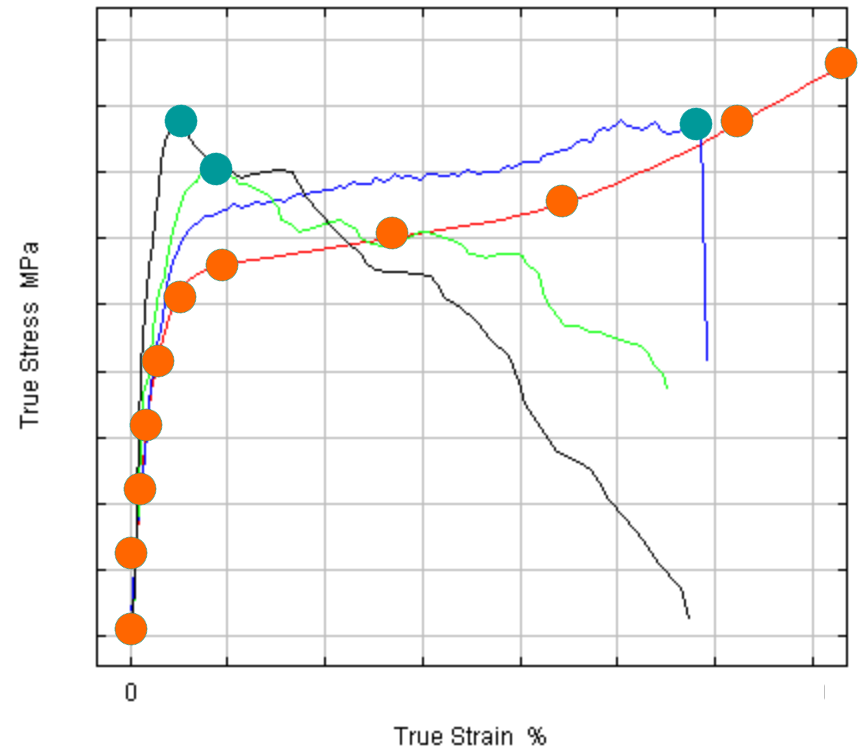
True Tensile Stress-Strain Curves



MAT 89 – Methodology

- Submit stress-strain curve ●
- Submit EMOD
- Submit rate dependency via LCSR-Eyring
- Submit failure strain v. strain rate via LCFAIL ●

True Tensile Stress-Strain Curves



MAT 89 – Workings

- Internally decompose quasi stress-strain curve
 - ◆ Use EMOD for von Mises limit
 - ◆ Rest of the curve is elastic-plastic
 - ◆ Rate dependency via LCSR
 - ◆ Failure via LCFAIL

Conclusions

- Choice of material model depends on
 - ◆ Material
 - ◆ Test data
- Proper selection = reasonable model
- Simple improvements can add power

Questions? go to *testpaks.com*

- CAE centric materials web-site
- Focus on material modeling
- Testing for CAE
- Supported by
 - ◆ DatapointLabs
 - ◆ CAE vendors
 - ◆ Expert users

The screenshot shows the homepage of testpaks.com. At the top, the logo features a stylized 't' icon followed by the text 'testpaks.com' and the tagline 'material modeling solutions for the CAE community'. A navigation bar includes links for Home, About, DatapointLabs, Partners, Newsletter, Submissions, and Advertise. The main content area is divided into several sections: a 'Buy TestPaks®' section with links for 'TestPaks By Application', 'TestPaks By Software', and 'Full Catalog'; a 'Material Modeling Strategies' section with links for 'Metals', 'Plastics', 'Rubbers', 'Foams', and 'Composites'; a search bar labeled 'Search Our Site' with a 'Go' button; a 'Good material models bring CAE closer to reality' article featuring a stress-strain curve graph and text about material testing; a 'Material Testing for CAE >> TestPaks® >> testpaks.com' link; a 'News' section with links to international conferences; and an 'Advertisements' section with a logo for 'matereality material data management'. The background of the website has a faint grid pattern.